European studies to advance development of inflatable and deployable decelerators

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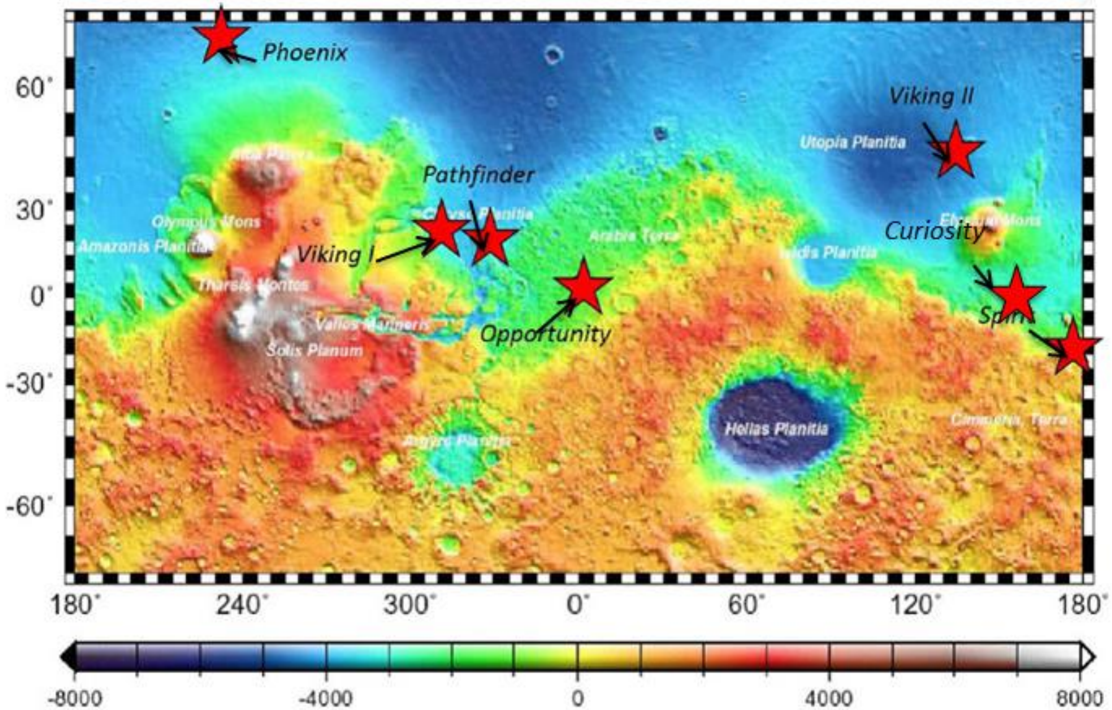
Motivation - Why decelerators?

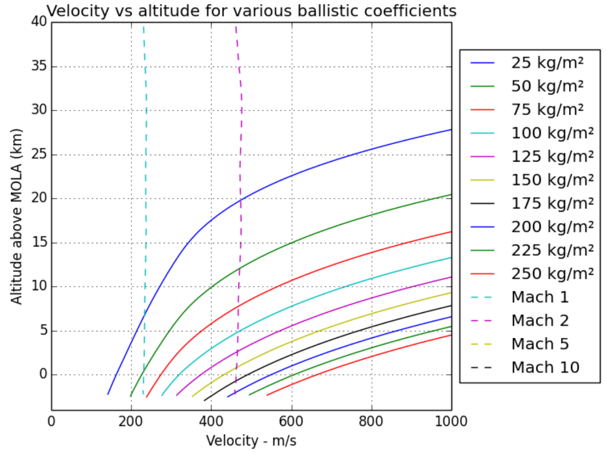
- Desire to land a heavy mass on Mars
  - Large scientific payloads - Manned mission precursors - Sample return
- Explore Mars Highlands
  - All missions so far are to lowlands
- Mass and landing altitude
  - Limited by current tech
  - Lifting entry helps a little

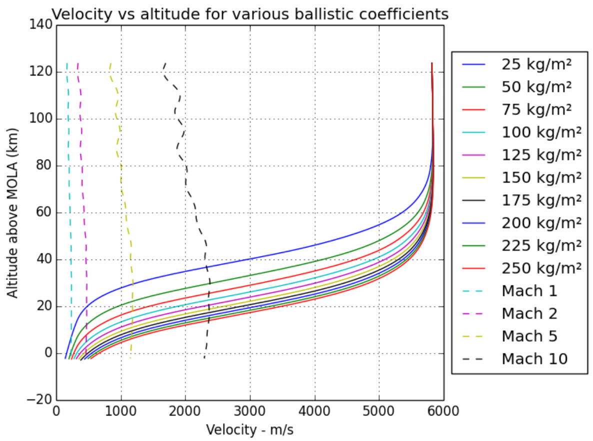


- Base Image: The Challenge of Mars EDL (Entry, Descent and Landing). Sostaric, R. Boston : JSC, 2010. JSC-CN-20470. Modified to add Curiosity.

Motivation - Why decelerators? (2)

- Landing Altitude and mass is limited by Ballistic Coefficient
- BC is constrained by launcher size
  - Assuming a conventional, rigid aeroshell
  - Maximum: 4.5 m using an Ariane 5
- Need 8 to 10 km AGL for conventional DLS
- Charts:
  - Shows requirements for high altitude landings
  - Supersonic parachute allows BC increase
  - Low altitudes at Mach 5
    - Works against supersonic deployment post entry
    - Shows need low BC throughout entry
- Reached limits of conventional EDLS
  - Need novel, unconventional technology



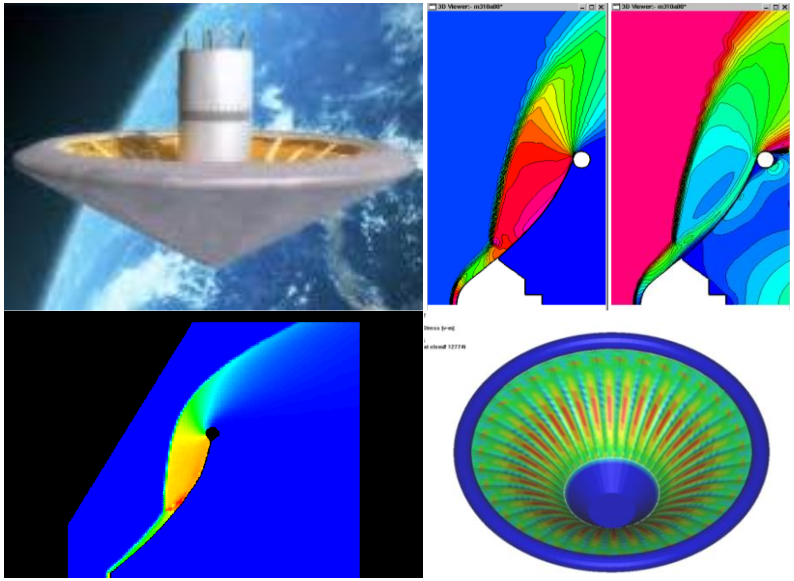


Motivation - Why decelerators? (3)

- Several possible solutions
  - Rigid lifting aeroshells
  - **Deployable/Inflatable aeroshells to augment size-limited rigid aeroshells**
  - Supersonic retro-propulsion
  - Supersonic inflatable aerodynamic decelerators
  - Improved thermal protection systems (eg. Dual pulse TPS to enable aerocapture, followed by entry)
- Two ESA Technology Research Programmes discussed further here
  - Aerothermodynamic Tools for Inflatable Hypersonic Decelerators
  - Deployable & Inflatable Heatshield & Hypersonic Decelerators

Aerothermodynamic Tools for Inflatable Hypersonic Decelerators

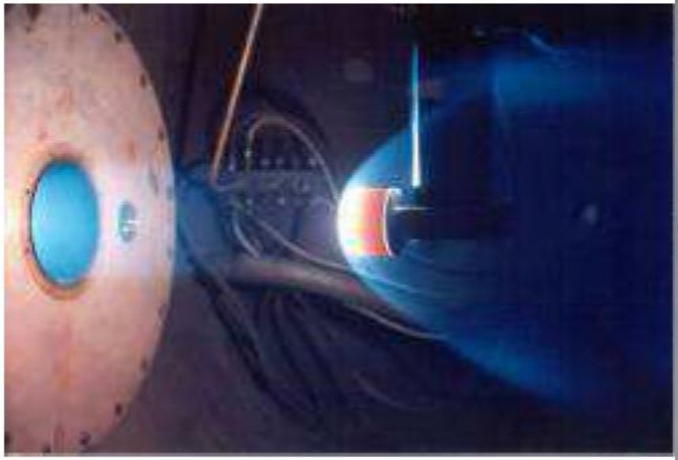
- Enabled capabilities and missions:
  - Analysis/design capability for IAD development
  - Tools, facilities and methods necessary to develop IADs
  - Aimed at a large mass or high-altitude landing on Mars, essential for MSR & manned missions
- Description of activities:
  - Reference missions and requirements
    - Verified by…
  - Test facility and analytical requirements
  - Parallel activity: Flexible TPS testing



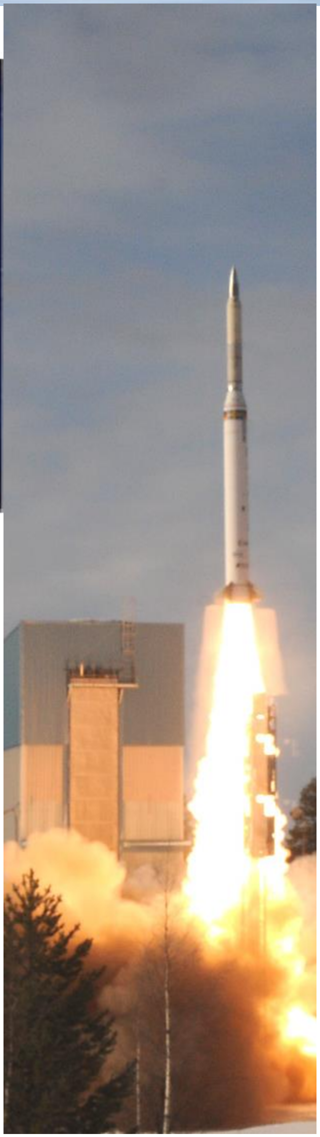
- Top Left: Inflation sequence for the IREV3 inflatable reentry test vehicle (Image: NASA/AMA)

Aerothermodynamic Tools for Inflatable Hypersonic Decelerators

- Ground testing
  - Wind tunnels
    - Aerodynamics
    - Structure
  - Plasma tunnels
    - Aerothermodynamics
- Free-flight testing
  - Sounding rockets
    - Aerothermodynamics and aerodynamics
  - Helium Balloons
    - Aerodynamics – dynamic stability
  - Ballistic ranges
    - Dynamic stability



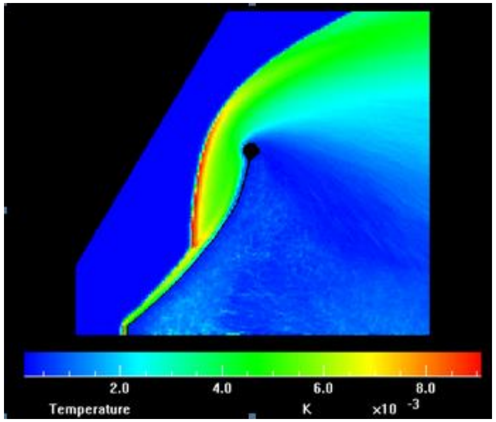
Credit: DLR.

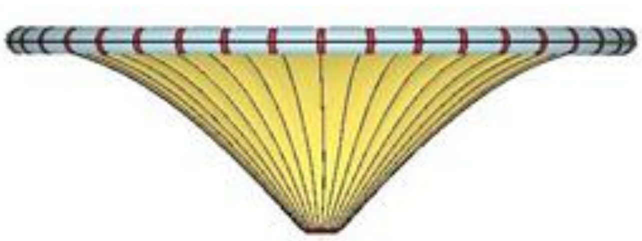


Credit: Astrium Space Transportation, Dr Irmin Meyer.

Aerothermodynamic Tools for Inflatable Hypersonic Decelerators

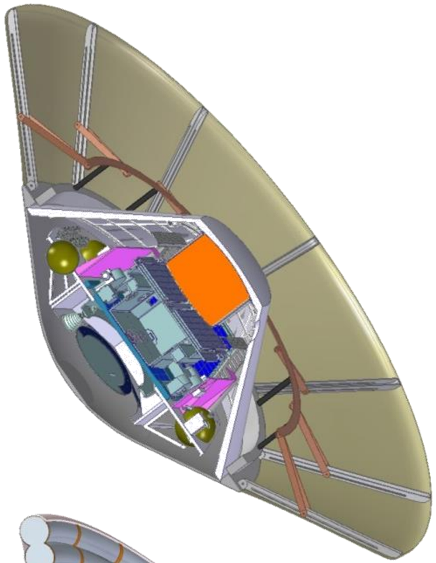
- Computational methods
  - Computational Fluid Dynamics
    - Shock interaction
    - Rarefied flow - DSMC
  - Fluid Structure Interaction
    - Effects of Deformation on flow
  - Structural modelling
    - Inflation and deployment
    - Load paths
  - Must be informed by test data
  - Can examine untestable conditions
- TRP Outcome: Capability development roadmap
  - Tools, facilities and methods necessary to develop IADs

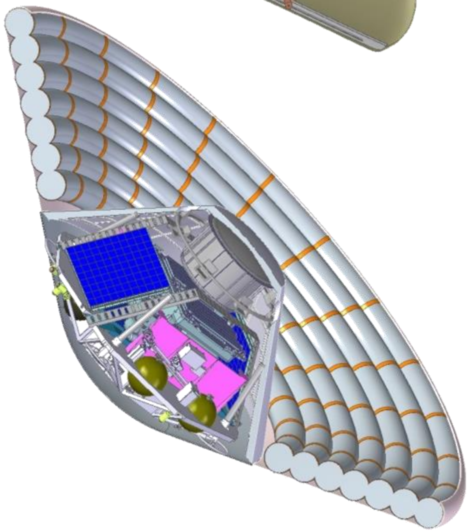




Deployable & Inflatable Heatshield & Hypersonic Decelerators

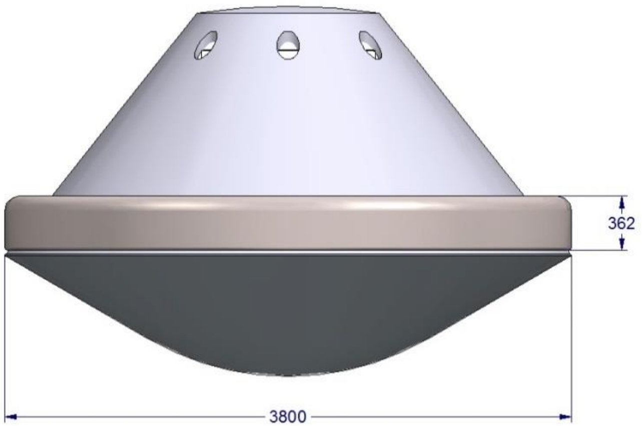
- Description of activities:
  - Definition of reference missions
  - Preliminary design of DAD & IAD
  - Technology screening and development planning
- Equal importance to both DAD and IAD
- Outcome: Development roadmap
  - For both IADs and DADs

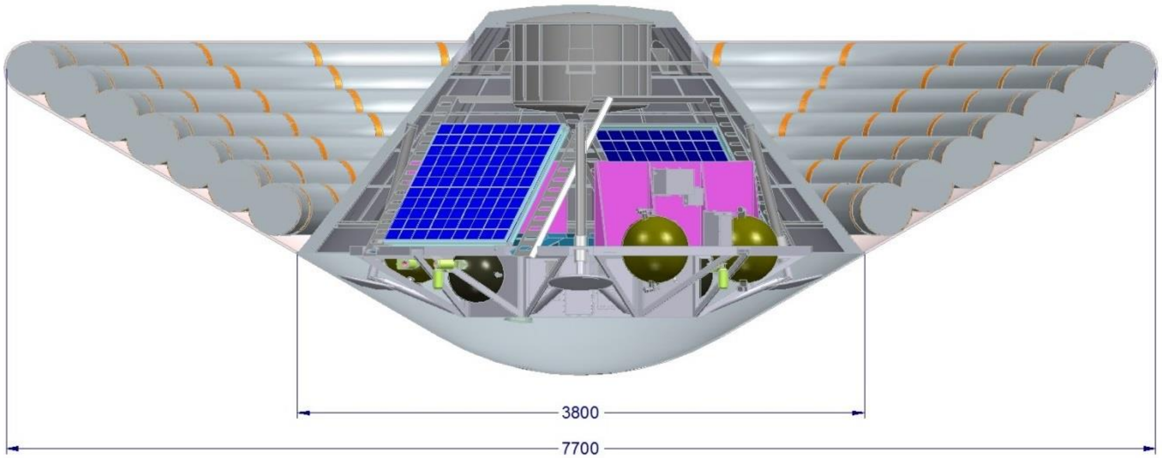




Deployable & Inflatable Heatshield & Hypersonic Decelerators

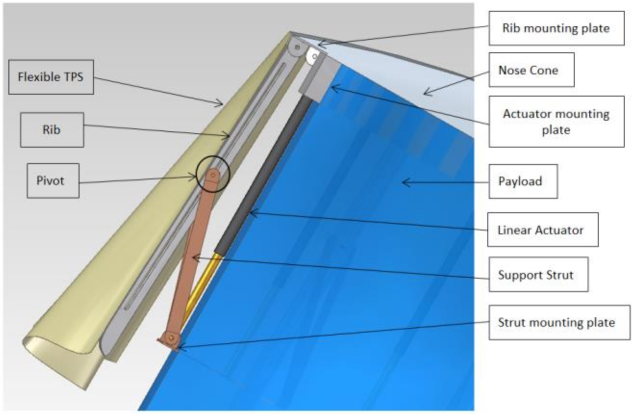
- Preliminary concepts
- Inflatable Aerodynamic Decelerator
  - ExoMars 2018 rover
  - Landing site 2km above MOLA
  - 7.7 meter inflated diameter
  - 3.8 meter packed diameter
    - Proton Launcher
  - ~500 kg IAD & structure

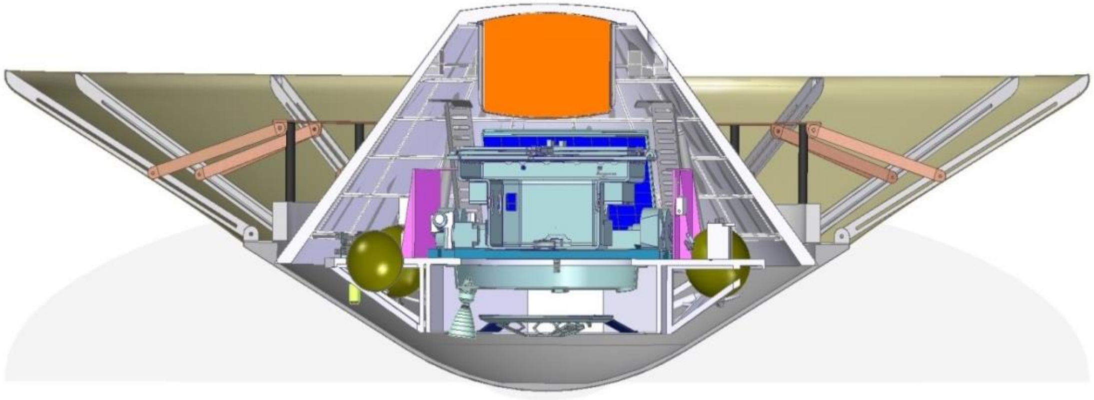


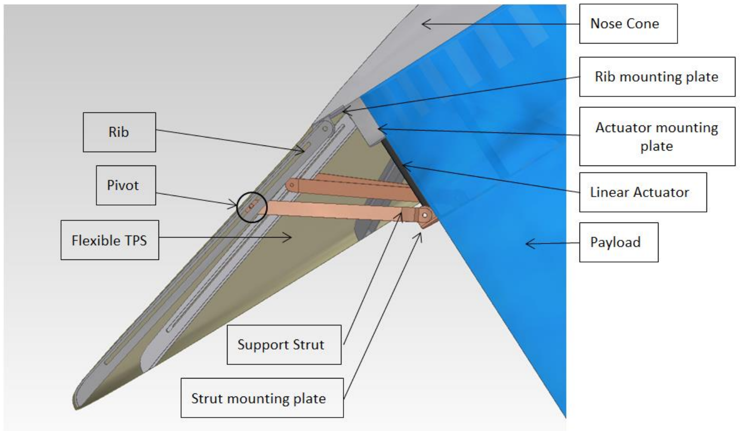


Deployable & Inflatable Heatshield & Hypersonic Decelerators

- Preliminary concepts
- Deployable Aerodynamic Decelerator
  - ExoMars 2018 rover
  - Landing site 2km above MOLA
  - 7.7 meter deployed diameter
  - 3.8 meter packed diameter
    - Proton Launcher
  - ~850 kg for DAD and structure







Conclusion

- Improvements to conventional EDLS required to further explore Mars
- Adding an Inflatable / Deployable Decelerator improves conventional EDLS technology
  - Large Landed Mass
  - Highlands
- Two European studies to advance development of inflatable and deployable decelerators
  - Tools and testing facilities and methods
  - Preliminary design for deployable and inflatable decelerators
  - Technology development Roadmaps
- The End